# EXPERIENCES WITH OTTA SEALS AND GRAVSEALS AS LOW COST SURFACING ALTERNATIVES FOR LOW VOLUME ROADS IN SOUTH AFRICA.

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**ABSTRACT**

*The geology of the North Eastern part of the province of KwaZulu-Natal, South Africa is predominantly alluvial with vast deposits of sands. Suitable gravel sources are hard to come by resulting in high gravelling and regravelling costs brought about by long haul distances and accelerated gravel loss.*

*The majority of gravel roads carry less than 500 vehicles per day of which less than 10 percent are heavy vehicles. The high cost of regravelling has led to consideration of upgrading of such roads to surfaced standard even though traffic volumes do not justify upgrading. Traditional chip seals are expensive and cannot be economically justifiable on roads that carry less than 500 vehicles per day. The KwaZulu-Natal Department of Transport is actively involved in efforts to identify cost effective alternative surfacing products for low volume roads. This paper outlines experiences derived from field trials with Otta seals and Gravseals, which have been used successfully in other countries as low cost surfacing products for low volume roads.*

*The Otta seal is formed by placing graded aggregates on a relatively thick film of soft binder that works its way through the aggregates due to traffic and rolling. Gravseal consists of a special semi-priming rubberized binder which is covered by a graded aggregate. Both Otta seals and Gravseals provide relatively flexible bituminous surfaces suitable for low volume roads. Cost savings are mainly derived from the broad aggregate specifications, which allow for the use of marginal materials.*

## INTRODUCTION

About 70 percent of the declared road network in the KwaZulu-Natal province of the Republic of South Africa is of gravel standard. Many parts of the province lack suitable gravel sources resulting in high re-gravelling costs brought about by long haul distances and accelerated gravel loss. The provision of low cost waterproof surfacing on such gravel roads, even under relatively low traffic, can be economically justifiable.

Traditional chip seals are used extensively in the province to upgrade gravel roads to surfaced standard. However, the high cost of the seals cannot be justified in gravel roads carrying less than 500 vehicles per day.. The KwaZulu-Natal Department of Transport is actively involved in efforts to identify cost effective alternative surfacing products for low volume roads. As part of this process, a number of trial roads and trial sections were constructed in the province to monitor and assess the performance of Otta seals and Gravseals. The characteristics and performance of some of the trial sections are discussed.

## CHARACTERISTICS OF GRAVSEALS

Gravseal consists of a special semi-priming rubberized binder which is covered with a graded aggregate *(1)*. The binder is an optimum blend of rubberized bitumen and medium solvents. This allows the gravel aggregate of the base to penetrate through the binder while depositing sufficient residual elastic binder on the surface to retain the graded aggregates. Suitable aggregates for the Gravseal are well graded and fall between 19mm and 2mm. The recommended grading envelope for Gravseal aggregates is shown in Figure 1. Construction of Gravseal involves the following steps:

- Broom the surface of the base with a mechanical broom to remove all lose and oversized materials
- Apply a light spray of water immediately before binder application to dampen the surface of the base.
- Apply hot binder at 120 $^{o}$C at the rate of 1.6 to 2.8*l*/m$^2$ and allowing the binder to penetrate the base for at least 20 minutes
- Covering the binder with aggregate spread at the rate of 1 m$^3$ of aggregate covering 100 - 110 m$^2$ of road surface and rolling with a pneumatic tyred roller.

**CHARACTERISTICS OF OTTA SEALS**

Otta seals consist of a 16 to 32mm thick bituminous surfacing composed of an admixture of graded aggregate in combination with a soft binder *(2).* The selection of a suitable binder type depends on the aggregate properties, the prevailing temperature conditions, rolling capacity and traffic volume. Suitable binders must be soft enough to initially coat the fines in the aggregates and rapidly move up through the matrix of aggregate voids by the action of rolling and traffic. The binder must be able to remain soft for long enough to continue to penetrate into the aggregate voids over a period of 4 to 8 weeks. Cutback bitumens in the MC3000 to MC800 viscosity range are the most common binders for Otta seals. Cutters are often used to reduce the viscosity of harder binders.

A wide range of aggregate grading can be used for Otta seals. The recommended grading envelope is shown in Figure 2. The maximum preferred particle size is 16mm although 19mm can be acceptable in the first seal in cases where a double Otta seal is constructed. Sufficient amounts of aggregate must be applied to ensure surplus material during rolling and throughout the initial curing period of the seal.

The construction of the Otta seal proceeds as follows:

- Broom the base free of all dust and any other foreign matter
- Lightly water the base to suppress dust and promote penetration into the base. The surface may or may not be primed prior to the application of the binder
- Apply aggregate at the rate of 1.3 to 2.0 m$^3$ of aggregate to 100 m$^2$ of road surface depending on the grading of the aggregate. The denser the grading , the higher the application rate.
- Apply the hot binder at the rate of between 1.6 and 1.9 *l*/m$^2$ depending on the grading of the aggregates.
- Roll the Otta seal using a pneumatic tyred roller until the aggregates can be seen pressing up between the aggregate particles. It is often necessary to repeat some passes of rolling a few days after the initial rolling.
- Allow traffic at controlled speeds over the newly surfaced road to assist with further kneading of the binder/aggregate admixture. Aggregates dislodged by traffic should be broomed back over the first 2 to 3 weeks of construction.

**PERFORMANCE OF GRAVSEAL TRIAL SECTIONS**

As part of experimenting with Gravseals, trial sections were constructed on a few gravel roads requiring upgrading to surfaced standard. The trial sections have been monitored from the time of construction of the seals. The observations made on the performance of the Gravseal surfacing are summarized for two trial sections.

**Main Road 443**

This road is a vital link between two towns. It carries about 300 vehicles per day. The base consisted of a chemically stabilized weathered rhyolite conforming to a G5 gravel *(3)* with CBR ranging from 49 to 59 at 95 % Modified AASHTO. A total of 7.4 km on steep sections between km 11+000 and km 21+500 were surfaced using Gravseal. The Gravseal binder was applied at the rate of 1.6 *l*/m$^2$. The aggregate was of high quality and within Gravseal specifications. It was sourced from a commercial quarry since suitable material could not be identified locally.

The performance of the Gravseal surface within the first 3 months was satisfactory. No major surface defects or bleeding occurred during this period. After 6 months, however, the road started to pothole progressively, making it necessary to reseal the road after 21 months.

**Main Road 235/1**

P235/1 connects two major towns and carried just over 500 vehicles per day. Some sections of the road are not surfaced. These sections require almost continuous blading during the dry season and are impassable over the rainy season making frequent regravelling necessary. Steep grades totaling 7.4 km between km 31+000 and km 48+000 were surfaced using Gravseal. The base was a chemically stabilized weathered dolerite gravel conforming to G5 *(3)* specifications. The Gravseal binder was applied at a rate of 1.6 *l*/m$^2$. The aggregate was also sourced from a commercial quarry due to lack of suitable local sources.

The seal was applied in January 2000 and is still in a fair condition today.

**PERFORMANCE OF OTTA SEAL TRIAL SECTIONS**

A number of trial sections were constructed in the eastern and north-eastern parts f KwaZulu-Natal to assess the performance of Otta seals. The characteristics and performance of two of the sections are discussed.

**District Road 435**

D435 is a secondary road which links two residential areas in the western outskirts of Durban. It carries an average of 500 vehicles per day of which 10 percent are heavy vehicles (4). The pavement structure consists of a 150mm chemically stabilized subbase conforming to G7 *(3)* specifications (Table 1). The base layer consists of a decomposed granite conforming to G5 specifications (Table 1).

Two types of aggregates were used for the Otta seal, a crushed quartzite rock and a decomposed granite. The crushed granite had good physical properties but with grading ranging from marginal to out of specification for Otta seals (Figure 3). The decomposed granite had a lower crushing strength but the same marginal grading (Figure 4). A 150/200 penetration grade bitumen was used as binder. It was cut back during spraying using 8 percent power paraffin where the crushed stone aggregate was used and 11 percent where decomposed granite was used. The binder was sprayed at the rate of 1.6 to 1.9 $l/m^2$.

The performance of the Otta seal was generally unsatisfactory. Within two months trial sections consisting of the natural gravel aggregates bled seriously in hot weather. A small proportion of oversized particles of the crushed stone aggregate which were retained on the seal could not be adequately bound. They were whipped out by traffic resulting in blemishes which later developed into potholes. The poor performance of the Otta seal on D435 was attributed to the grading of the aggregates which was mostly out of specification and to lack of experience in the construction of Otta seals. The trial sections were the first attempt by the Department of Transport in constructing Otta seals.

**Main Road 50**

P50/2 is a provincial road linking Nkandla town and the forest. It carries about 300 vehicles per day most of which are mini buses and cars (4). The pavement structure consists of a subbase conforming to G7 *(3)* specifications and a crushed sandstone base conforming to G4 specifications (Table 1).. The binder used for the Otta seal was a 150/200 penetration grade bitumen cut back using 8 percent paraffin and sprayed at the rate of 1.7$l/m^2$. The aggregate used was sourced from a commercial quarry and met the specifications for Otta seal.

Apart from isolated cases of bleeding and potholing, the performance of the Otta seal has been satisfactory. It is worth noting, however, that the aggregates used for the Otta seal on this road were of comparable quality to chippings used in chip sprays. Under the circumstances, the observed performance is more an indication of the performance of a chip seal than an Otta seal.

## CONCLUSIONS

The performance of both the Gravseal and Otta seal was generally unsatisfactory except in cases where high quality aggregate was used. This can be attributed in part to grading, which was partly outside the recommended envelope for the sections that performed poorly. Lack of experience in constructing these types of seals played a part as well.

Because both types of seals are flexible, rutting and corrugations can occur as a result of Otta seals and Gravseals following the contour of the base. Adequately compacting and finishing base layers can avoid these. The time interval between base preparation and seal construction should also be minimized.

Despite the shortcomings highlighted, both Otta seals and Gravseals have the potential to become low cost surfacing alternatives especially where aggregates for conventional seals are unavailable or too expensive. More field trials involving a variety of aggregate types and grading need to be carried out in South Africa to broaden the knowledge base before concrete conclusions can be made.

## REFERENCES

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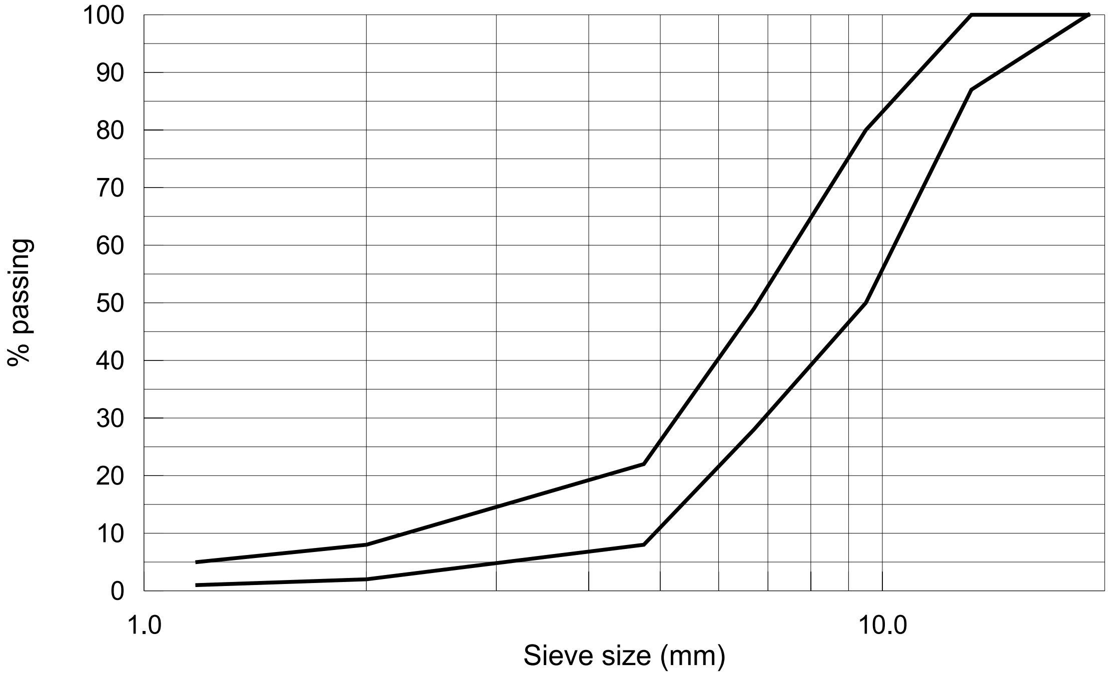


**FIGURE 1 Recommended grading envelope for Gravseal**

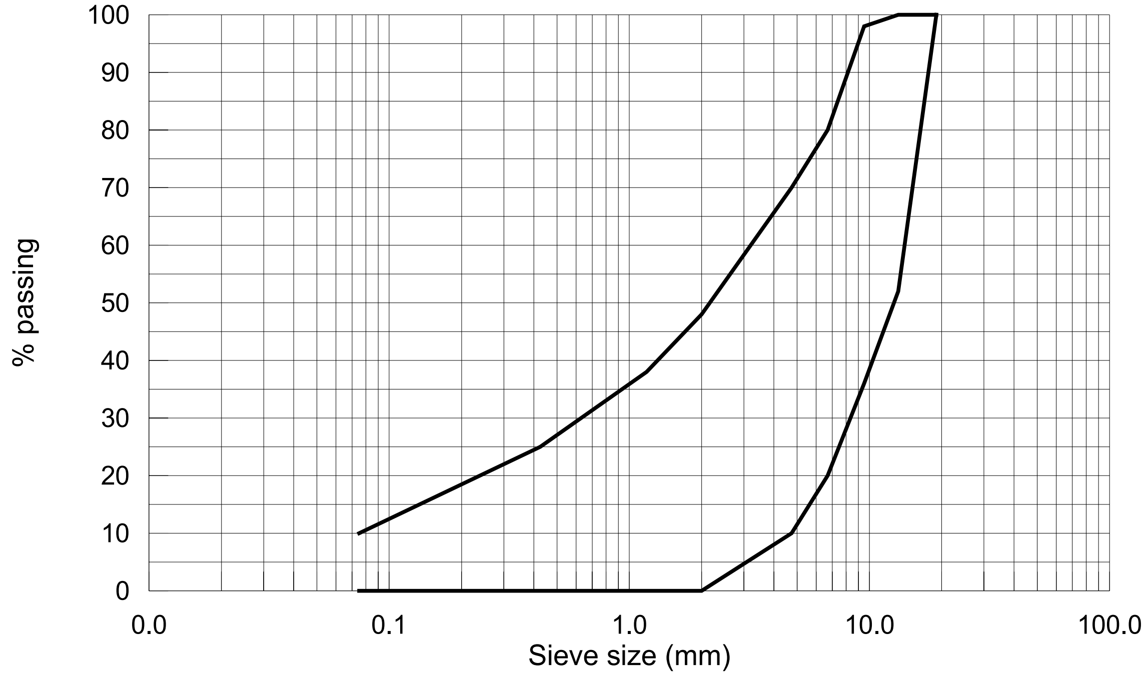


**FIGURE 2 Recommended grading envelope for Otta seal**

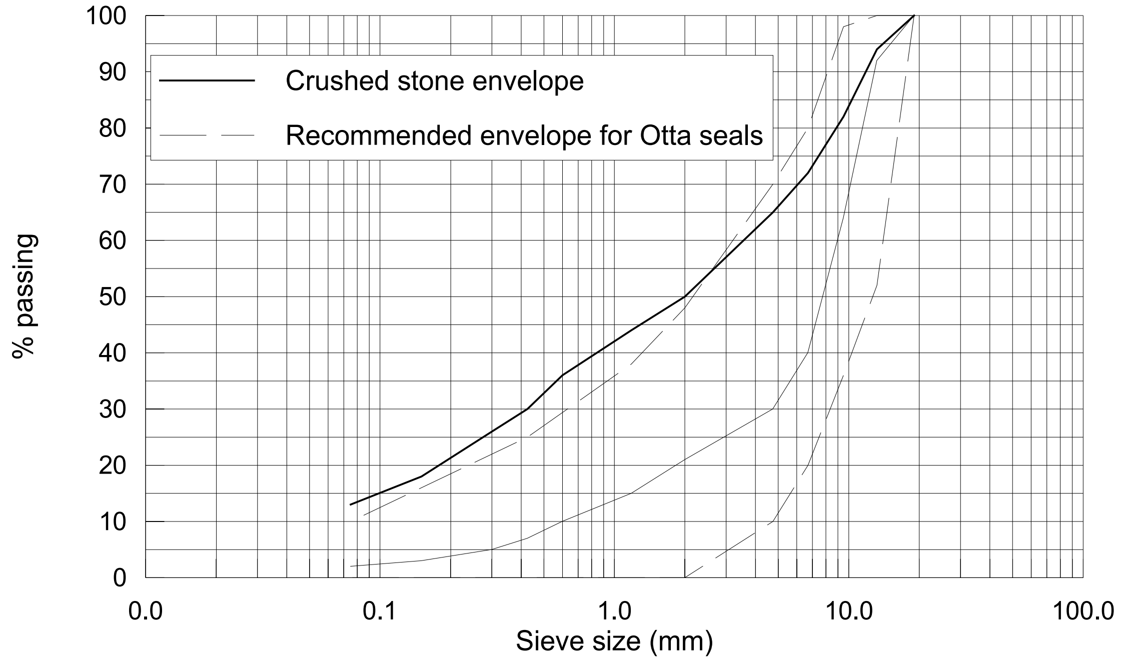


**FIGURE 3 Grading envelope for crushed stone aggregates**

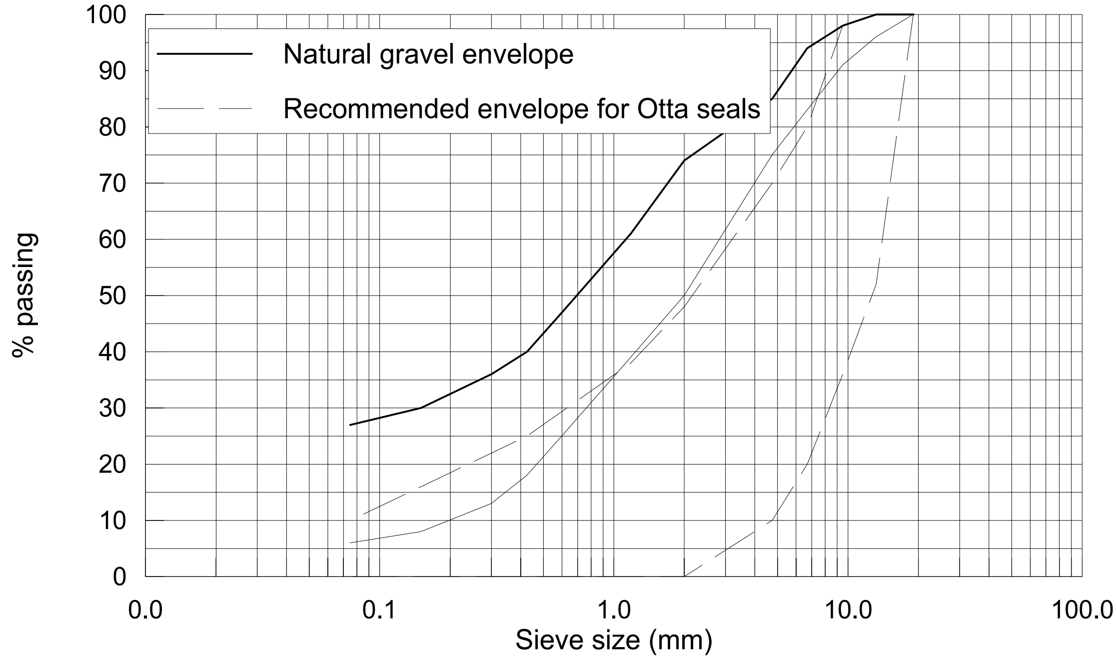


**FIGURE 4 Grading envelope for natural gravels**

**TABLE 1 Material Specifications for Pavement Design based on TRH4**

| CODE | MATERIAL | ABBREVIATED SPECIFICATIONS |
|---|---|---|
| G1 | Graded crushed stone | Dense – graded unweathered crushed stone; Maximum size 37,5mm; 86-88% apparent relative density; soil fines P1<4 |
| G2 | Graded crushed stone | Dense – graded crushed stone; Maximum 37,5mm; 100-102% Mod. AASHTO or 85% bulk relative density; soil fines P1<6 |
| G3 | Graded crushed stone | Dense – graded crushed stone and soil binder; Maximum 37,5mm; 98-100% Mod. AASHTO; soil fines P1<6 |
| G4 | Crushed or natural gravel | Minimum CBR = 80% @ 98% Mod. AASHTO; Maximum size 37,5mm; 98-100% Mod. AASHTO; P1<6; Maximum Swell 0,2% @ 100% Mod. AASHTO. For calcrete P1≤8 |
| G5 | Natural gravel | Minimum CBR = 45% @ 95% Mod. AASHTO; Maximum 63mm or 2/3 of layer thickness; Density as prescribed layer usage; P1<10; Maximum Swell 0,5% @ 100% Mod. AASHTO. |
| G6 | Natural gravel | Minimum CBR = 25% @ 95% Mod. AASHTO; Maximum 63mm or 2/3 of layer thickness; Density as per prescribed layer usage; P1<12; Maximum Swell 1,0 @ 100% Mod. AASHTO. |
| G7 | Gravel/Soil | Minimum CBR = 15% @ 93% Mod. AASHTO; Maximum size 2/3 of layer thickness; Density as per prescribed layer usage; P1<12 or 3GM + 10; Maximum Swell 1,5 @ 100% Mod. AASHTO. |
| G8 | Gravel/Soil | Minimum CBR = 10% @ 93% Mod. AASHTO; Maximum size 2/3 of layer thickness; Density as per prescribed layer usage; P1<12 or 3GM** + 10; Maximum Swell 1,5 @ 100% Mod. AASHTO***. |
| G9 | Gravel/Soil | Minimum CBR = 7% @ 93% Mod. AASHTO; Maximum size 2/3 of layer thickness; Density as per prescribed layer usage; P1<12 or 3GM** + 10; Maximum Swell 1,5 @ 100% Mod. AASHTO***. |
| G10 | Gravel/Soil | Minimum CBR = 3% @ 93% Mod. AASHTO; Maximum size 2/3 of layer thickness; Density as per prescribed layer usage or 90% Mod. AASHTO. |